FSTC-HT-23-413-68

AD690399

U.S. ARMY FOREIGN SCIENCE AND TECHNOLOGY CENTER

FEB 17 1971
BOREAL INSTITUTE
LIBRARY

SURFACE ICING (NALED') AS A NEGATIVE PHYSICAL

AND GEOLOGICAL PHENOMENON

COUNTRY: USSR

TECHNICAL TRANSLATION

Distribution of this document is unlimited. It may be released to the Clearinghouse, Department of Commerce, for sale to the general public.

AD D C
REF
JUL 29 1969
A

Pam: 551.343.74: (*532.5) BOL

POLAR
PAM
2268
POLARPAM

AD690399.

BOREAL INSTITUTE
LIBRARY

TECHNICAL TRANSLATION

FSTC-HT-23- 413-68

SURFACE ICING (NALED') AS A NEGATIVE PHYSICAL AND GEOLOGICAL PHENOMENON

by

S. M. Bol'shakov

SOURCE: AUTOMOBIL'NYKH DOROGAKH
TRANSPORT, MOSKVA
Vol. 7, 1966
USSR

Translated for FSTC by Techtran Corporation

This translation is an unedited rendition of the original foreign text. Statements or theories advocated or implied are those of the source and do not reflect the position or opinion of the US Army Foreign Science and Technology Center. This translation is published with a minimum of copy editing and graphics preparation in order to expedite the dissemination of information. Requests for additional copies of this document should be addressed to the Defense Documentation Center, Cameron Station, Alexandria, Virginia, ATTN: OSR-2.

Rec'd: 17
Order No.: 4340 B.
Price: 3 00
Acc. No.: Clearinghouse

00592

Digitized by the Internet Archive
in 2022 with funding from
University of Alberta Library

https://archive.org/details/surfaceicingnale00bols

SURFACE ICING (NALED') AS A NEGATIVE PHYSICAL AND GEOLOGICAL PHENOMENON

A considerable number of studies and articles are devoted to the subject of ice layers and the methods of preventing their formation. Technical instructions and recommendations in the fight against ice layers on railroads and motor roads and in construction have recently been published. They recommend a number of radical anti-icing measures and facilities which are being used in actual practice /12, 15/.

Mention should be made at the same time of the still inadequate study of the ice-forming process as a physical and geological phenomenon. The characteristic features of the origin and development of ice layers in various geological and hydrogeological conditions are not quite clear. The nature of the changes of such an important factor as the hydrothermal regime of the soil and water streams resulting from the interference with the natural condition by the construction of installations has not yet been thoroughly studied. The methods of predicting ice formation and the theoretical basis for the anti-icing methods being used are therefore still inadequate. As a result, the construction of roads is, as a rule, followed by an increase in the quantity and size of the ice layers, and the choice of the anti-icing measures in this connection is based primarily on volition which frequently makes them ineffective.

Ice layers are a complex physical and geological phenomenon occurring in certain combinations of specific climatic characteristics, geological structure and hydrogeological conditions. A cold climate with early and severe frosts and a thin snow cover produces favorable conditions for the formation and development of ice layers. At the same time there are vast areas in the north of our country characterized by severe climatic conditions and a very limited development of ice layers. This is explained either by the absence of subterranean water or by the fact that the composition of the rocks, the nature of their

occurrence and tectonic displacement prevent the emergence of the subterranean water to the day surface.

Determining the importance of the physical and geological factors in the origin and development of ice layers, it may be assumed that the climate represents the necessary medium, the geological structure the cause and the subterranean water the source of the ice formation.

Permafrost is not necessarily a factor in the formation of ice layers. A considerable number of them develop outside the permafrost areas. Resistant to water, a shallow permafrost merely intensifies and complicates the ice-forming process. Let us take a look at the effect of the physical and geological conditions on the origin and development of ice layers in the case of various areas in Siberia.

There are nine ice formations in the western part of the Taishet-Lena road area which is 400 kilometers long, and 95 formations in the eastern part which measures 320 kilometers. The uneven development of the ice-forming processes along the road is determined not so much by the climate, although it is severer in the eastern part, as by the varying geological structure, the frozen soil and hydrogeological conditions of the area. The geological section along the road justifies the following conclusion. The western portion of the road from Taishet to Bratsk is made up of argellites and sandstones of the Bratsk and Kezhemsk suites which are characterized by a limited water-bearing capacity. The bedrock water is drained by a thick talus layer of the mountain slopes and does not usually emerge to the day surface. The thick layer of sandy-gravelly alluvium in the river valleys facilitates a free filtration of the infrabed water during the winter. Permafrost occurs in limited areas along the bottom of marshy valleys. When frozen over, the weak superpermafrost water without a definite runoff produces only small cumulose hummocks. Thus there are no factors in this area contributing to the development of ice layers.

Similar conditions are found in the central part of the road where it runs along the Angara river valley. Although the Mamyr suite sandstones there are characterized by a considerable water content, the subterranean water has no outlet to the day surface. It is drained by a thick layer of terrace sandy gravelly formations of the Angara river.

This accounts for the fact that the 80-kilometers stretch contains only three ice layers produced by the small rivers, which are fed by subterranean water in their upper reaches.

The eastern part of the road runs along the river valleys which cut through the carbonate rocks of the Ust'-Kut suite and into the argellites of the upper Elena suite. The abundant fracture and karst and stratal and fissure water, representing permanent rich sources and feeding the local river drainage in the winter period, are confined to the carbonate rocks.

Most of the medium and small rivers of the Ilim, Kupa, Kuta and Lena systems are fed by these subterranean waters in their upper reaches or along their way, and form large ice layers in the area of the road. The springs are particularly numerous in the area where the carbonate rocks come in contact with the water-resistant argellits. The development of ice layers in this area is most intensive in point of quantity and the volume of the ice.

The development of ice layers on the eastern part of the road is intensified by the severer climate and the presence of permafrost which is characterized by an insular occurrence along the bottom of the marshy valleys and mountain slopes of northern exposure. The emergence of springs to the day surface at various slope levels is caused by the permafrost. In the winter the mountain slopes are covered with ice layers produced by the frozen superpermafrost water as well as individual springs of subterranean water. Such areas are extremely unfavorable for construction purposes and they should therefore be bypassed in the course of exploration by building the roads higher on the slope.

The mentioned characteristic development of ice layers in the area of the Taishet-Lena road covers an insignificant territory in the southern part of the Siberian platform with analogical physical and geological conditions, including the area of the planned road to the Ust'-Ilim Hydroelectric Power Plant.

Still more pronounced is the effect of the physical and geological factors on the formation of ice layers in other Siberian areas.

The extensive development of ice formation in the north of the West Siberian lowland is prevented by the thick layer

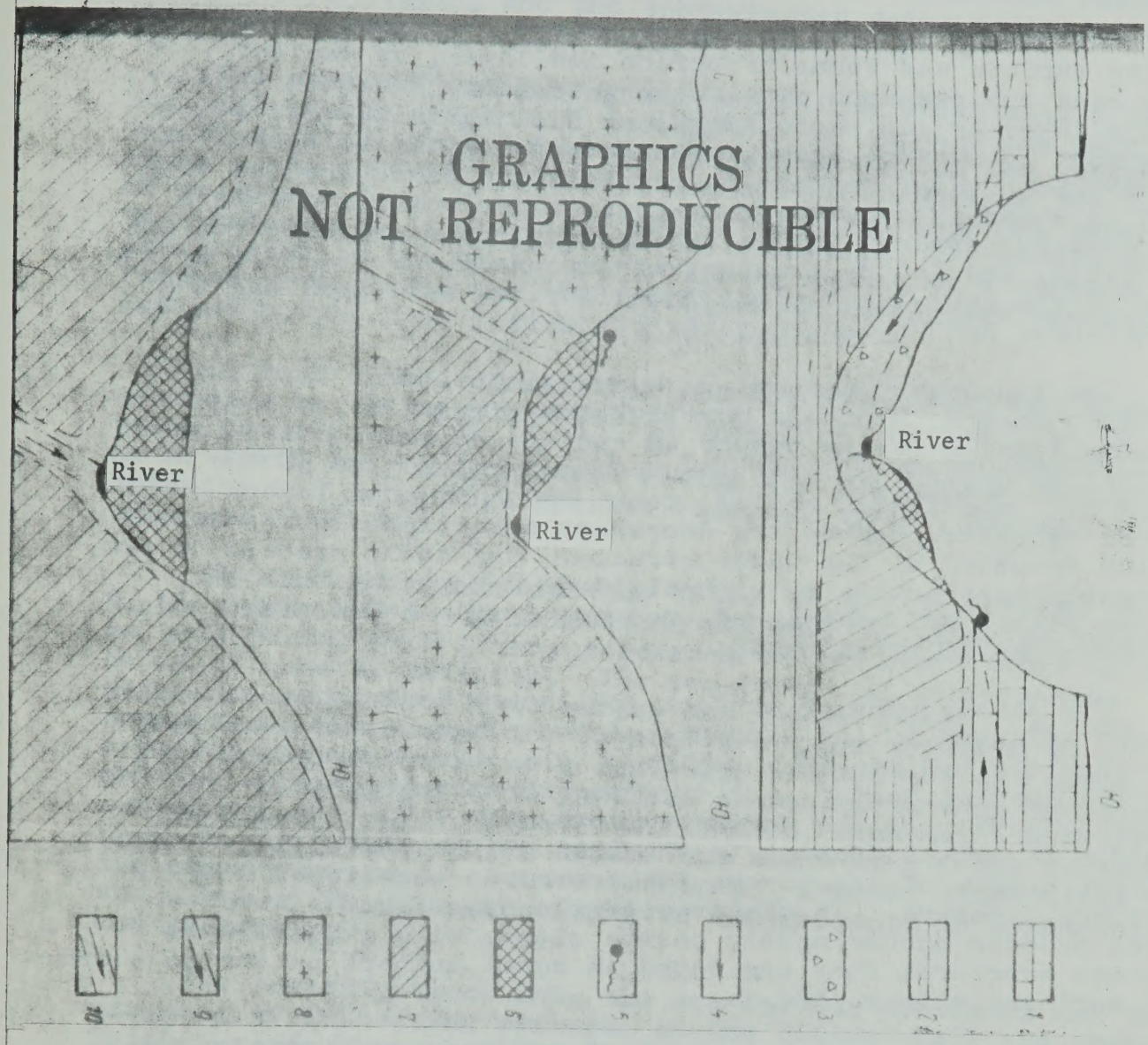
of sandy-gravelly formations, the flat and slightly dissected topography, the continuous permafrost and limited number of outlets for large springs of subterranean water.

In the mountainous areas of Yakutia and the Transbaikal Region as in the parts of the Siberian platform with mountain-valley relief, the geological conditions are favorable for the formation of huge reserves of subterranean waters and their outlets to the day surface in the form of powerful permanent springs which feed the river drainage and facilitate the development of ice layers. At the same time, the diverse geological structure of these areas and their hydrogeological and frozen-ground conditions also determine the varying nature of the ice-layer formations (see figure). Within the Siberian platform the ice layers are formed by the gravity springs of fissure-karst water, primarily on the northern slopes and in the river valleys (figure a). In the Transbaikal Region they are formed by the ascension springs of subterranean fissure water, primarily on the southern slopes (figure b). In Yakutia the icing process is fed by powerful streams of infrapermafrost water emerging from the tectonic fault zones to which the streams are also confined /1, 9, 13, 18/.

Whenever the river flow is fed only by precipitation and limited ground water, its discharge is gradually reduced with the coming of the winter. The lower discharge is accompanied by a reduction of the free-flow section because of the thickening ice layer which prevents any additional surface icing. If an alluvial sedimentation stratum is found under the riverbed, some of the river water may flow in the form of a subriverbed stream when the free-flow section of the river is reduced.

Similar conditions are observable in the north of the West Siberian lowland.

When the rivers are fed by subterranean springs emerging in the riverbed or near it, the freezing of the water flow and the reduction of its discharge are uneven processes. The springs of deep subterranean water with a stable yield produce a permanent discharge of the stream in wintertime. At the same time the growing thickness of the river ice steadily reduces the free-flow section. This is facilitated by the formation of bottom ice and the intensified freezing of the stream at the sandbars, rapids and other crowded places of the river as well as the road installations allowing for the passage of water.



The physical and geological conditions governing the development of the icing process

a-on the Siberian platform; b-in the Transbaikal region; c-in Yakutia; 1-carbonate rock of the Ordovician period with abundant fissure and karst water which produces gravity springs; 2-a water-resistant stratum of Cambrian argillites; 3-crushed talus formations; 4-direction of the water flow; 5-spring; 6-surface ice layer; 7-everfrozen rocks; 8-igneous rock; 9-tectonic fissures with ascension springs of internal water; 10-tectonic fault zones with large ascension streams of infra permafrost water which feedsthe gigantic ice-sill layers.

The result is that the water breaks through the ice, spreads on its surface and forms a surface ice layer, or "naled". In this case the presence of a water-resistant bed and a thin alluvium layer or its poor filtration will contribute to the development of surface icing. The more powerful the spring of subterranean water feeding the stream the larger the ice layer. This is observable in the Yano-Indigirka river system where the powerful springs (up to 3 m^3/sec) produce gigantic surface ice sills, and in the Transbaikal Region /1, 9, 13, 18/, in the area of the Amur-Yakut motor road /16/, as well as along the Taishet-Lena and Zeya-Nora road /2, 3/.

The topography also plays a substantial part in the ice-forming process: there is more subterranean water, a bigger discharge and a larger number of springs on a dissected relief. The relief determines also the hydrological regime of the springs. Waterfalls, rapids, rocky beds and thin layers of alluvial deposits produce the necessary conditions for an intensified freezing of the water streams. The icing process is considerably more active on high-altitude topography than on planes with a well developed drainage system and considerable alluvium and alluvial water.

The development of surface ice layers is to a considerable extent affected by the exposure of the slopes which also determines the hydrothermal regime of the soil and streams. In the Transbaikal Region, for example, the icing process takes place primarily on the southern slopes /1, 13/. The author found a reverse situation in the area of the Taishet-Lena line: a large number of ice layers are formed on the slopes with a northern exposure. In the area of the Amur-Yakut highway the icing process occurs mostly on the slopes with a western and eastern exposure; they are found in equal numbers on the southern and northern slopes /14/.

The predominant development of surface ice layers on the southern slopes in the Transbaikal Region and on the northern slopes of the Siberian platform is due to the different physical and geological, especially geocryological conditions existing in these regions (See figure). On the southern warm slopes of the Transbaikal Region, where there is no permafrost, the ascension springs of subterranean fissure water easily find an outlet to the day surface. On the Siberian platform where the northern slopes are characterized by the insular occurrence of everfrozen rocks, the gravity springs of fissure and karst water, blocked by these water-resisting rocks, emerge to the

surface and form ice layers. There are no everfrozen rocks on the southern slopes, and the subterranean water filters through the thawing soil.

The physical and geological conditions which play a leading part in the origin and development of surface ice layers may be used as a basis for the classification of the latter. There is no uniform classification system of surface ice layers at present. Some of the existing classifications are based on the characteristic features of the relief /5, 7/; others are established on the basis of the spring outlet or a complex of factors responsible for the formation of ice layers without indicating the main factor /1, 16, 17, 20/.

In most of the classifications the ice layers are divided according to the origin which is determined by the type of water feeding them /4, 8, 10, 14, 17/. Thus A. M. Chekotillo, A. A. Tsvid and V. N. Makarov divide the ice layers (naledi) into the following five groups: fluvial, spring, ground, melted snow and mixed /17/.

The fullest classification of ice layers is offered by M. I. Sumgin and N. I. Tolstikhin who classify the ice layers as originating from river, subterranean and mixed water on the basis of genetic criteria. The ice layers of subterranean water are subdivided into spring and ground types. In this connection, the ground ice layers "are those produced by a freezing ground stream or a stream of superpermafrost water, and the spring-type ice layers are those produced by freezing spring water" /10/. This classification, eventually expanded by N. I. Tolstikhin /14/, became the basis of all the following classifications. It now requires a further elaboration in the light of the latest scientific achievements in hydrogeology and geocryology.

The investigations into the ice-forming processes and the planning of anti-icing measures on the Taishet-Lena and Abakan-Taishet roads show that the classification should be simple and based on the major distinctive features determining the origin of the ice layer.

In the event of field investigations based on the appearance of the ice layer, such a classification will make it possible to determine the type of water feeding it and take appropriate anti-icing measures.

The classification based on the physical and geological

indicators determining the dynamics, regime and magnitude of the icing process, recommended by the author, is designed to meet these requirements. Under this classification, the ice layers are divided according to the type of water feeding them and the presence of this water in the rocks (Table 1).

The first type includes ice layers formed by the surface streams of varying size ranging from small ones, active only in the first half of the winter, to medium sized and large rivers such as the Lena, Yana, Indigirka, Nora, etc. These streams are fed primarily by precipitation and, to a lesser extent, by subterranean water. The reason for the formation of type I ice layers is the narrowing or freezing of the stream where the freezing process is most intensive, and the emergence of the water onto the ice through the cracks in the icy hummocks and open water spaces in the ice.

Such ice layers are divided into ice layers of large and medium sized rivers with alluvial deposits and infrabed water, and ice layers of small streams which have no well developed bed or alluvial deposits. The conditions of these ice layers and their formation vary which determines the different methods of fighting them.

The same type includes also the ice layers produced by the melting snow /17/. They are not widespread and will therefore not be discussed in detail.

The second type includes ice layers formed by every type of groundwater including superpermafrost water. According to the recommendations contained in the methodical instructions on the compilation of hydrogeological maps /6/, the subterranean waters (vadose water, groundwater level, ground basins and streams) form one of the uppermost hydrogeological zones, the ground water zone. These waters have a local feed area and a very unstable regime; their formation is directly affected by the atmosphere, surface water, climate, soil and vegetation as well as the lithological composition of the rocks.

The second type of ice layers may be formed by superpermafrost and groundwaters. The ice layers must be divided on this basis (Table 1) because the regime of these waters varies. The development of the ice layers and the methods of fighting them will therefore be different. These ice layers are produced by the freezing ground waters emerging to the day surface when the water-bearing stratum freezes over and is reduced in size. Most

Table 1

Type of ice layer on	Subtype of ice layer	Characteristic external features of the ice layer	Characteristic regime of the ice layer
1. Surface water	A. Fluvial water (river) B. Small streams	Originate in the stream channel and spread on the surface of the river ice; the outline of the "naled" is similar to that of the channel; the ice surface is flat or concave, occasionally convex with drops and scattered cumulose hummocks. The ice is thinly laminated, pure white and blue with interlayers of snow and air.	The characteristic conditions begin with the onset of very cold weather, and the larger the river, the later they begin; they last until the end of the cold weather. In the case of small streams the growth of the surface ice layer ceases by the end of the first half of the winter
2. Ground water	C. Ground water	A small area and small ice thickness; its elongated shape extends across the ground water stream and the gradient. Such ice layers are formed in the area of rapids, paths and breaks in the relief. Underground it is shaped like cumulose hummocks. The ice is granular, it contains congealed snow and its color is slightly similar to that of the surrounding ground.	They are fed by unstable and limited-yield ground water, develop early and last not more than two-three months.
	D. Superpermafrost water	Very similar to the ice layers of the ground water but smaller in area and thickness; they frequently form cumulose hummocks, especially on flat areas where the flow of water is insignificant or nonexistent. They extend across the stream and gradient. They form along roads and paths, in hollows and drainage ditches.	They are produced by superpermafrost water freezing on the surface of the ground, and are characterized by a low temperature, small yield and unstable regime; they appear with the first severe colds and last not more than one-two months.

Table 1 (cont.)

Type of ice layer	Subtype of ice layer	Characteristic external features of the ice layer	Characteristic regime of the ice layer
	E. Subterranean water (spring)	Extends along the gradient, ravines and river-beds. The area and thickness of the ice are considerable. Characterized by the presence of hummocks and hydrolaccolites. The ice is mostly pure, blue and obliquely laminated.	Produced by the freezing water of the permanent springs of subterranean water which is characterized by a stable regime, the ice layer exists throughout the winter and frequently forms enormous accumulations of ice.
3. Subterranean water	F. Inter- and infrapermafrost internal water (ice sills)	Enormous in size. Some of the Yakutian ice sill are 100 km long, 3-5 km wide and 10-13 meters thick. Their area usually exceeds a million square meters, and their volume is about one million cubic meters and larger. They develop in river valleys and may extend to mountain slopes and watersheds. Alternating ice layers and open spaces are observable along the water stream. This type of "naled" (ice layer) includes hydrolaccolites.	Associated with the internal infra-permafrost water emerging from the tectonic fissures and faults, and characterized by a low temperature, stable conditions and abundant water supply, these ice layers appear with the first frosts and grow throughout the winter forming enormous accumulations of ice: the ice layers frequently last many years.
4. Mixed water		Distinguished by a combination of forms and features peculiar to ice layers on rivers, ground and subterranean water with prevailing features of the predominant type	The characteristic features and dynamics of the ice layers are determined by the type of water feeding them

of the ice layers of this type are elongated in shape and extended across the flow of the groundwater and the local gradient, and occur wherever the ground freezes harder.

The third type consists of ice layers formed by subterranean and internal water, interpermafrost and superpermafrost water, stratal and fissure and fissure and karst water as well as tectonic fissure water. The first subtype includes ice layers formed by subterranean water emerging to the day surface in the form of springs or in depressions and foundation pits. The second subtype includes ice layers formed by deep interpermafrost and superpermafrost water emerging through the tectonic cracks to the day surface in the form of powerful permanent springs which form unique hydroeffusive ice sills and gigantic ice layers in northern Yakutia.

The fourth subtype includes ice layers originating from and simultaneously fed by various types of water in various combinations. It is necessary to single out this type of mixed ice layers as they are characterized by a multiformity and large size, and they are very difficult to fight as the methods to be used in this connection must be complex.

Recommendations of the most rational anti-icing methods are given in Table 2 in accordance with the geological characteristics, permafrost-hydrogeological conditions, thermal ice regime and other general properties of the ice layers. The recommendations are preliminary and require further elaboration.

Based on physical and geological conditions, the classification of ice layers and appropriate anti-icing measures facilitate a better organization of field investigations and development of such measures.

It was established in the course of road construction that the number and size of the ice layers tend to increase considerably after the construction of the installations. Construction disrupts the established natural conditions and produces a negative effect on the thermal and ice regime of the water streams which in turn activates the icing process. Inasmuch as the causes behind the origin and development of ice layers following construction are different than in the case of the previously existing ice layers, the methods of fighting them should therefore also be different.

Table 2

Type of ice layer	Anti-icing measures
Ice layers on surface water	In the case of large natural ice layers forming on a river above its intersection with a road, the opening in the bridge and the height of the embankment are increased to facilitate a free passage of the ice. In the case of a considerable yield and positive thermal balance of the stream, the latter should be passed through the installation before it reaches the freezing point. A stream with a negative thermal balance near the installation is passed through (the installation) by the use of a trough which may be heated if necessary; also by cleaning, straightening and deepening its bed. Retaining the ice layers on small streams.
Ice layers produced by ground water	The section is dried and the water level lowered by means deep ditches and troughs; in the case of ice layers formed by supserpermafrost water the surface of the permafrost ground is lowered. The formation and retention of the ice layer far from the installation by the introduction of frozen belts, screens and fences and by raising the embankment and covering it with draining soil. Cracking and removing the ice from openings in the installations to allow for the passage of the spring water.
Ice layers produced by subterranean water	The sources of water are drained or dammed and channeled off across the road whenever water-bearing strata are opened and the road intersects nearby springs. In all other cases the channel of the stream is controlled and an optimal thermal regime of the water flow created by concentrating it and building special troughs for the passage of the water through the installation; increasing the openings in the installation and the preferential construction of bridges. Gigantic and large ice layers should either be bypassed or enabled to pass through the installation. On small streams far from a road the ice layers are retained by levees and fences.
Ice layers produced by mixed water	The complex methods employed are determined by the type of water feeding the ice layer and the natural conditions.

It would therefore be expedient to divide the ice layers on the basis of origin into the following two types: natural and artificial.

The natural ice layers are those occurring and developing in natural conditions peculiar to a certain area prior to its exploitation. The reason for their development is a combination of unfavorable physical and geological conditions.

The artificial ice layers are those occurring in the course

of exploitation of a particular area due to the disruption of the hydrothermal regime of the surface and subterranean waters and loose ground. Such disruptions are produced by the construction of various installations, tree-felling and the removal of the vegetative and moss cover as well as by digging pits and ditches in the water-bearing strata or narrowing the flow of groundwater beneath the installations under construction. The failure to take the necessary prophylactic measures to prevent icing in the planning period also contributes to the development of artificial ice layers.

The struggle against the natural ice layers includes the proper selection of anti-icing measures and devices appropriate to the engineering and geological conditions of the thermic ice regime. This struggle may be maintained in the following two directions: 1) the planning of installations that would take into account the free passage of ice layers, as for example a high bridge with a large opening, and 2) the elimination of the causes of icing or the retention of the ice layer before it extends to the road.

The basic method of fighting "artificial" ice layers is the development of prophylactic measures during the exploration and planning period that would prevent the formation of ice layers or reduce them to a size that would not be dangerous to the installations under construction. There were no such ice layers before the construction of the installation and we must therefore prevent their development after the construction. This is the top priority goal in the fight against ice formation.

Having established the natural patterns of the development of ice layers which are determined by the physical and geological conditions of a particular area, it is possible to predict to some extent the surface ice-formation processes connected with construction. The first such prediction was made during the planning of the Taishet-Lena road and later the Abakan-Taishet road. The prediction was basically correct.. Appropriate measures were taken in most of the places of expected icing during the planning of artificial installations and the roadbed. As a result, no icing developed in any of the hollows. The most rational types of water-passing devices permitted by local conditions were used on the ice-covered streams. But the development of "artificial" ice layers could not be prevented. The reason for that was the inadequate study of the changing hydrothermal regime of the streams and grounds in their interaction with the road under construction.

To solve that problem, the Novosibirsk affiliate of the Central Scientific Research Institute of Communications and the Tomsk State Planning Institute of Transportation organized the first experimental grounds in 1961 along the Taishet-Lena line, under the direction of the author, for the study of the hydrothermal regime of the ice-covered streams and grounds near the water-passing installations. Eventually, these investigations were continued by D. N. Herkulov, a graduate student of the Scientific Research Institute of Railroad Transportation. The results of those investigations has facilitated a better understanding of the hydrothermal regime of the streams and grounds of various types near the water-passing installations.

The successful resolutions of the problem of fighting ice formation calls for a further study of this complex physical and geological phenomenon both in natural conditions and in its interaction with various constructions.

The solution of this problem will be very helpful in the special studies of the ice-forming process on the roads of northernmost Siberia and the organization of experimental grounds and observation stations along them.

* * *

BIBLIOGRAPHY

1. Baranov, I. Ya. The Southern Fringe of the Permafrost Region. Hydrogeology of the USSR, No. XVII "Vostochnaya Sibir", (Eastern Siberia), Book 2. Moscow-Leningrad, Gosgeologizdat Press, 1940.

2. Bol'shakov, S. M. Artificial Installations on Streams Characterized by Icing and on Perennial Permafrost. Transportnoye Stroitel'stvo (Transport Construction), 1960, No. 3.

3. Bol'shakov, S. M. Ice Formation and Its Effect on the Construction of the Taishet-Lena Railroad Line. In the book titled "The Stability of Railroad Installations Under The Effect of Frozen Ground Conditions". Transactions of the Central Scientific Research Institute of Communications, No. 57. Moscow "Transport" Press, 1964.

4. Kalabin, A. I. Springs and Ice Layers Produced by Subterranean Water in the Northeast of the USSR. Transactions of the All-Union Scientific Research Institute No. 1. Geocryology (Merzlotovedeniye), No. 7, Vol. 7. Magadan, 1958.

5. Makarov, V. N. Anti-icing Devices on the Urgal-Izvestkovaya Railroad Line. "Transport Instruction in the Permafrost Region", Report No. 121. Moscow, Central Scientific Research Institute of Communications, 1958.

6. Methodical Instructions on the Compilation of Hydrogeological Maps. Moscow, Gosgioltekhizdat Press, 1960.

7. Nizovskin, G. A. Preventing the Formation of Ice Layers on Railroads. Moscow "Transport" Press, 1964.

8. The Bases of Geocryology, Part I. Moscow, Academy of Sciences Press, 1959.

9. Simakov, A. S. Certain Characteristic Features of the Development of Ice Sills in the Northeast of the USSR and the Probable Structure of the Cryolitic Zone. Information on General Geocryology. Moscow, Academy of Sciences Press, 1959.

10. Sumgin, M. I. and Kachurin, S. P., etc. General Geocryology (Obshcheye Merzlotovedeniye). Moscow, Academy of Sciences Press, 1940.

11. Targulyan, Yu. O. Artificial Installations on Ice-Covered Streams. Moscow, Avtotransizdat Press, 1961.

12. Technical Instructions on Research, Planning and the Construction of Railroads in the Permafrost Region (VSN 61-61). Moscow, Mintransstroi Press, 1962.

13. Tolstikhin, N. I. The Subterranean Water of the Transbaikal Region and its Hydrolaccolites. Transactions of Commission for the Study of Permafrost, Vol. 1. Moscow, Academy of Sciences Press, 1932.

14. Tolstikhin, N. I. Subterranean Water of the Frozen Lithosphere Zone. Moscow, Gosgeolizdat Press, 1941.

15. Instructions on the Use of Anti-icing Measures on Highways, Moscow, Avtotransizdat Press, 1962.

16. Utkin, B. V. The Basic Methods of Fighting the Intensive Ice Formation on Highways. "Transport Construction in the Permafrost Region" (Voprosy transportnovo Stroitel'stva Rayona Vechnoi Merzloty", Report No. 121. Moscow, Central Scientific Research Institute of Communications, 1959.

17. Chekotillo, A. M., Tsvid, A. A. and Makarov, V. N. Surface Ice Layers in the USSR and the Fight Against Them. Blagoveshchensk, Amur Book Press, 1960.

18. Shetsov, P. F. Brief Review and the Prospects for the Study of the Gigantic Ice Layers in Yakutia. Geocryology (Merzlotovedeniye), Vol. I. Moscow, Academy of Sciences Press, 1946.

19. Shushakov, Ye. V. Protecting the Roadbed Against the Formation of Ice Layers. In the Collection titled "The Construction and Exploitation of a Roadbed on Dust-Like Ground". Moscow, "Transport" Press, 1964.

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
Foreign Science and Technology Center
US Army Materiel Command
Department of the Army

2a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

2b. GROUP

3. REPORT TITLE
Surface Icing (Naled') As a Negative Physical And Geological Phenomenon

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Translation

5. AUTHOR(S) (First name, middle initial, last name)
S. M. Bol'shakov

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
19 June 69	16	N/A

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	FSTC-HT-23- 413-68
c. 9223628 2301	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d. AMXCR-TL	ACSI Control Number (None)

10. DISTRIBUTION STATEMENT
This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	US Army Foreign Science and Technology Center

13. ABSTRACT

The inadequate study of the icing processes on the railreads and highways of the Siberian Platfrom is said to be largelyresponsible for the failure to develop appropriate anti-icing measures. Permafrost and various hydrogeological subterranean conditions are responsible for the "natural" formation of ice layers, while the construction of road installations is conducive to "artificial" icing as a result of their interference with natural processes. Greater research efforts in geocryology, hydrogeology and the geological structure of the areas under consideration are suggested, with particular emphasis on road construction in the permafrost region.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Geocryology, hydrogeology, permafrost, superpermafrost water, infrapermafrost water, hydrolaccolites, insular bedding, cross-bedded ice						

D I S T R I B U T I O N

FSTC

1	AMXST-OC
1	AMXST-RD-RE
1	AMXST-RD-PB
9	AMXST-RD-RT
1	AMXST-RD-AF
6	AMXST-RD-RF
1	AMXST-WS
1	STIT-EUR
1	STIT-FE
1	FSTC LN OFC, WPAFB
1	AMXST-GE

AMC

1	AMCRD-I
5	AMSMI-YDL
1	AMCRD-T
2	AMSTE-AD-E
8	STEAP-FI
1	STEBD-SB
1	STEBB-AD-S
1	STEBA-AJ
1	STEBG-PR
1	STEBC-PA
1	AMXRES-TPI
1	SMEFB-AI(FIO)

OTHER

15	DIACO-3
2	FTD-TDBTL (Tech. Lib.)
20	DDC-IR
1	ARMY MAP SERVICE - 13451
1	CIA LIBRARY
1	CIA - CTS
2	STIC-4
1	ASD ASFS-2, WPAFB
3	USASA-DCSOPS
1	ASSISTANT SECRETARY OF THE ARMY (R&D)
1	OCRD
1	USAWC
1	USASA-TISB
1	USACDC
1	ACSI-AID
1	ACSI-DFIS
1	SAMSO(SMFA)

Date Due

00592

Pam:
551.343.74:
(*532.5)
BOL

BOL'SHAKOV, S. M. "Surface icing..

DATE DUE	BORROWER'S NAME	ROOM NO.

00592

BOREAL INSTITUTE
LIBRARY

University of Alberta Library
0 1620 0332 8398